Integration of a Miniaturized Conductivity Sensor into an Animal-Borne Instrument

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LONG-TERM GOALS

Habitat changes affecting marine mammals can range from small scale cyclic changes (e.g. tides) and natural physical processes (e.g. fronts and eddies) to changes on an ecological scale that range from years to decades and from tens to thousands of kilometers. These habitat changes can be natural or anthropogenic (e.g. pollution, sound). For example, short-term changes of the physical environment can cause changes in marine mammal populations by affecting pup survival, while long-term unidirectional changes can result in permanent habitat change or even habitat loss that may have a significant impact on entire populations. Population consequences of the foraging behavior of marine mammals depend on the availability of prey, which in turn is in part driven by the way animals react to the quality and dynamics of their immediate environment at the scale they are able to sample it. Predicting how marine mammal populations respond to habitat changes is also essential for developing conservation management strategies. To investigate such links, we need the appropriate environmental information at the relevant scales and, while large scale monitoring of environmental change can be accomplished cost-effectively by approaches such as remote sensing, getting fine scale information from the marine mammal's immediate environment requires local in-situ monitoring.

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The availability of information about the marine environment has rapidly improved over the last two decades. The Global Ocean Observing System (GOOS) is now providing a range of observations measured from space, ships, moored instruments, free floating buoys and profilers to accurately describe the present state of the oceans. Compared to twenty years ago, this relative abundance of data is providing a global view of the ocean system that can support operational ocean services worldwide, but is still struggling to provide data at the appropriate scales to link oceanographic observations to animal movements, especially in the high latitude seas; nor was it ever designed for such use.

One rapidly developing approach has been information using the animals themselves to carry the required instruments to collect in-situ environmental data. Such data is necessarily at an appropriate scale to link changes in animal behavior to changes in their environment. However, existing instruments capable of providing data at the necessary accuracy are limited in available attachment methodologies and the size of instruments can render other approaches difficult. This project aims to be a stepping stone in developing an instrument enabling accurate measurements while the instrument is rotating around a barb attachment as is used to tag large cetaceans. Such methodology would provide for ecosystem studies of large cetaceans that are not currently feasible.

OBJECTIVES

The aim of this project is to modify and improve an existing miniature conductivity-temperature sensor that can deliver oceanographic information and incorporate this sensor into the proven design of a Satellite Relay Data Logger (SRDL), which can collect behavioural information simultanously. Electrodes will be used to measure conductivity which will enable us to and therefore reducing the measurements errors in inductive cells due to to the variable proximity of the animal carrying the tag due to the attachment method. After the design and proof-of-concept stages the performance of the instrument package will be tested by using it to collect data to demonstrate it can obtain data of sufficient quality to investigate the links between animal behavior and local physical conditions.

Little bit here about freeing up space for other sensors?

APPROACH

The best way to improve the quality and quantity of the data from animal-borne sensors in both aspects (more sensors and minimizing the external field) and decreasing the size of the CTD package is the use of an electrode based conductivity sensor. These tend to be smaller in size than inductive sensors. However, there is a trade-off between size and accuracy. Decreasing size resuls in a decreased accuracy. In addition, by minimizing the energy consumption the signal to noise ratio decreases as well. Therefore, an optimum has to be found between size, energy consumption and accuracy to design a working electrode based conductivity sensor within the constraints of animal-borne instruments.

This project is thought to be a stepping stone towards a highly sophisticated animal-borne instrument, which can deliver highly accurate surface and subsurface locations associated with behavioral and environmental information. The aim of this project is to modify and incorporate an existing miniature, high precision conductivity and temperature sensor into the satellite relay data logger system designed and built by the SMRU Instrumentation Group, University of St Andrews, UK. The result would be an animal-borne instrument, which can record behavioral and oceanographic information useful or high accuracy, whose conductivity measurements are not influenced by the attachment method and

potentially, will be either smaller than the existing CTD-SRDL or can incorporate e.g. an Iridium/GPS antenna, while keeping the same size.

The University of Southampton together with the Sensors Development Group at the National Oceanographic Centre Southampton (NOCS), UK, developed a miniature conductivity and temperature sensor system (CT-sensor) in recent years. The sensor head and the electronics were developed for stand-alone deployments and tested over 7 weeks attached to a floating buoy in the North Atlantic. It consists of a multi electrode conductivity cell with a platinum resistor bridge to produce an integrated CT sensor and is combined with an impedance measurement circuit to support the sensors and to create a CT sensor system. Within this project, we want to adapt the hardware and software of this existing NOCS sensor package for easy integration into the SRDL design, so that the data can be relayed via telemetry and that the sensor is suitable for long term deployments on marine mammals. This will be done in two main stages. During the first stage, the existing CT-sensors will be modified for easy integration into the existing SRDL. The CT package will then be intergrated into the SRDL tested in the lab. After the successful proof-of-concept phase, we will refine the hard- and software, before the complete package will be tested during an at-sea deployment.

WORK COMPLETED

The project started in August 2013 and we are in the early proof-of-concept stage. One post-doctoral researcher was hired and started to work on this project. Two requirements were defined for the CT-sensor for integration into the existing SRDL concept. The first requirement is an interface system that has to be provided with the CT-sensors to create a CT-package that can exchange information with the SRDL. While the size of the CT-package is not a driving factor at this early stage, loose size restrictions have to be adhered to to enable it to be fitted at the side of the existing SRDL to open up the top space for other sensors such as GPS. The complete potted CT-package needs to fit initially into a cuboid with sides of 60 by 25 by 20mm. Work to fullfill these requirements has started.

RESULTS

The interface for easy communication between the CT-package and SRDL was determined to be an I_2C interface with a Serial Data Line (SDA) and a Serial Clock (SCL). In addition three more connections will be necessary: a connection for the supply voltage (Vbat) of 100mA peak current and a voltage between 3.4V and 3.7V; a common ground (GND) and an ENABLE connection, which can be used to power on or off the CT-sensor completely (0V=off, Vbat=on) to conserve energy. The communication between the SRDL and the CT-sensor has to implement three I_2C slave commands.

- Read conductivity in low power, low resolution mode to determine if the instrument in the water or not (WET-DRY mode)
- Read conductivity and temperature at high precision (near) simultaneously and filtered to match time-constants if necessary to avoid salinity artifacts. The resolution should be 16 bits distributed over the ranges of -10C to 55C for temperature (resolution 1mK) and 0-80mS/cm in conductivity (resolution 1.25 µS/cm)
- Write command(s) to store calibration data.

  Such interface will speed up the integration process into the existing SRDL, but will also enable others to integrate the CT-package easily.

IMPACT/APPLICATIONS

Other research groups already registered interest in the final product to be used with rotating barb attachments to tag large cetaceans to support ecosystem studies of large cetaceans in the Arctic.